
SFMR Retrieval Algorithm Update

Heather M Holbach

FSU COAPS, NGI, NOAA/AOML/HRD

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Motivation for Update

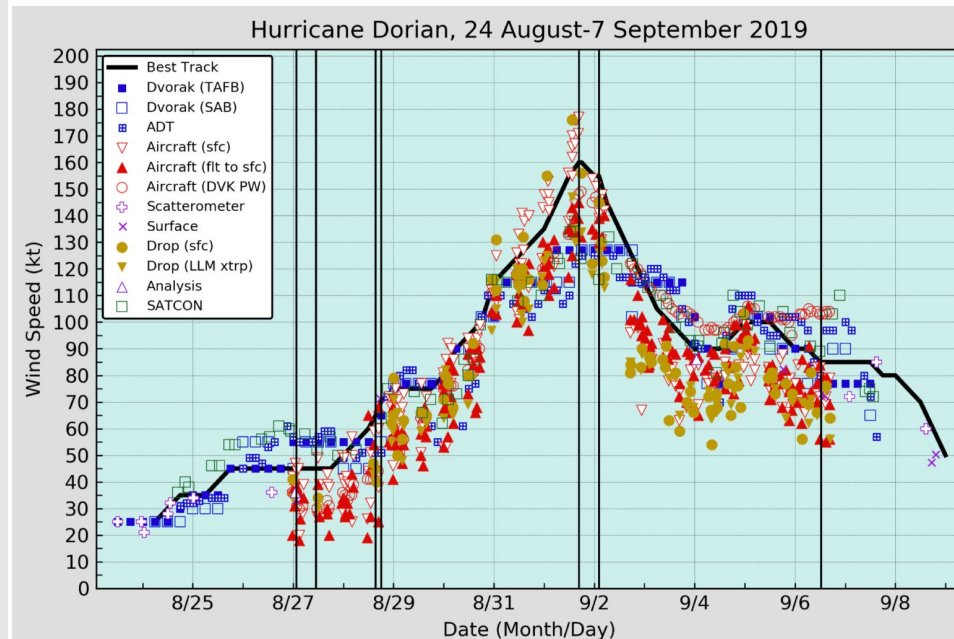
- The National Hurricane Center (NHC) has noticed inconsistencies between the dropsondes, SFMR, and flight-level surface wind speed estimates
 - Especially in major hurricanes
- Accurate estimation of intensity and wind structure is necessary for accurate forecasts of intensity and potential impacts

Hurricane DORIAN

ZCZC MIATCDAT5 ALL
TTAA00 KNHC DDHHMM

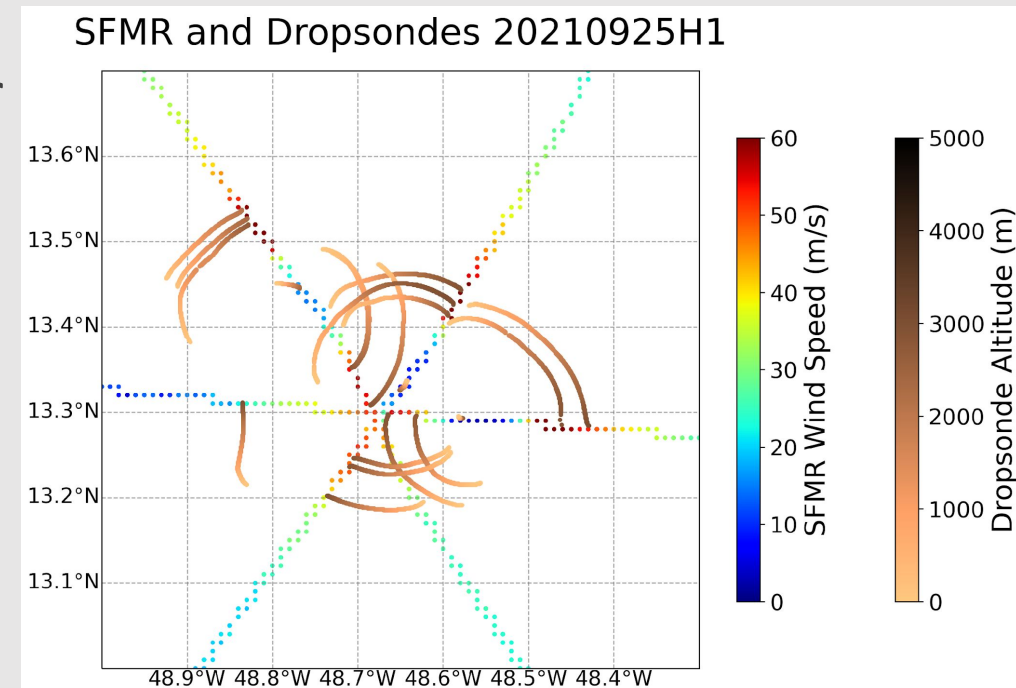
Hurricane Dorian Discussion Number 31
NWS National Hurricane Center Miami FL AL052019
1100 PM EDT Sat Aug 31 2019

Data from both Air Force and NOAA Hurricane Hunter aircraft indicate that Dorian remains a very powerful hurricane, and the satellite presentation is still quite impressive with a very stable, well-defined eye. There has been no evidence of concentric eyewalls in aircraft or microwave data, which is somewhat surprising given that the intensity has been at category 4 strength for 24 hours. Both aircraft measured peak flight-level winds that support an initial intensity of 130 kt. There have been some higher surface wind estimates from the SFMR, but these data are questionable based on our experience of very high SFMR-measured wind speeds in recent strong hurricanes that didn't match standard flight-level wind reductions.

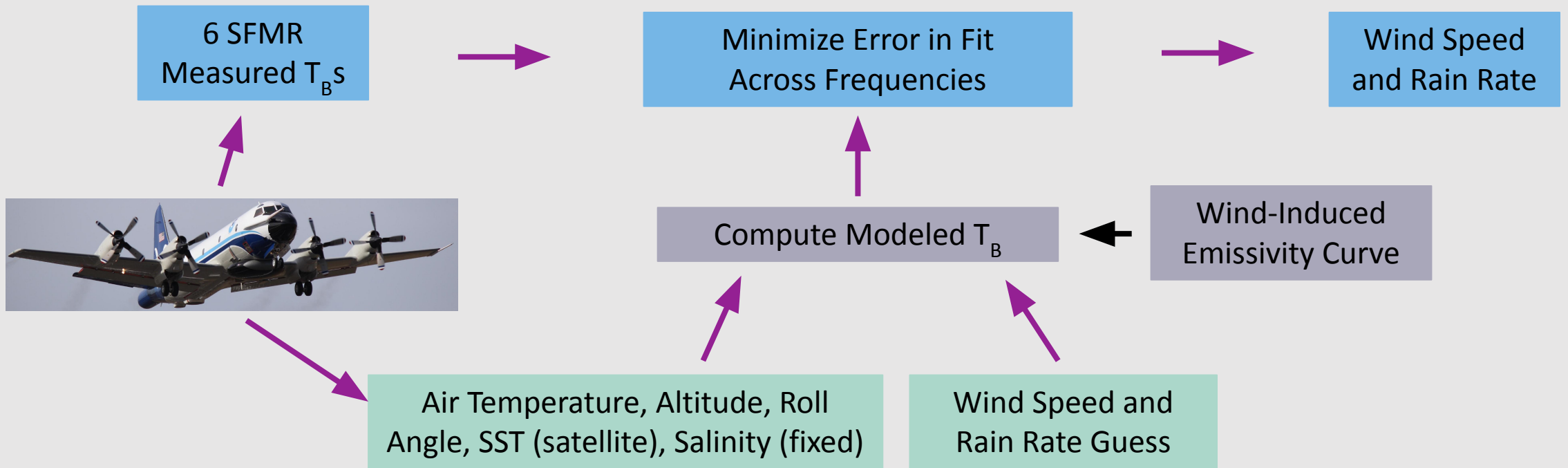


SFMR and Dropsondes

- SFMR algorithm relies upon match-ups with dropsondes
 - Wind-induced (excess) emissivity model function trained on dropsondes
- Prior algorithm updates (Uhlhorn et al. 2007, Klotz and Uhlhorn 2014) had few dropsondes above 50 m/s
 - Additional dropsondes and SFMR data in major hurricanes have been collected since 2014
- In eyewall, dropsondes drift downwind leading to spatial difference in SFMR and dropsonde surface wind observations



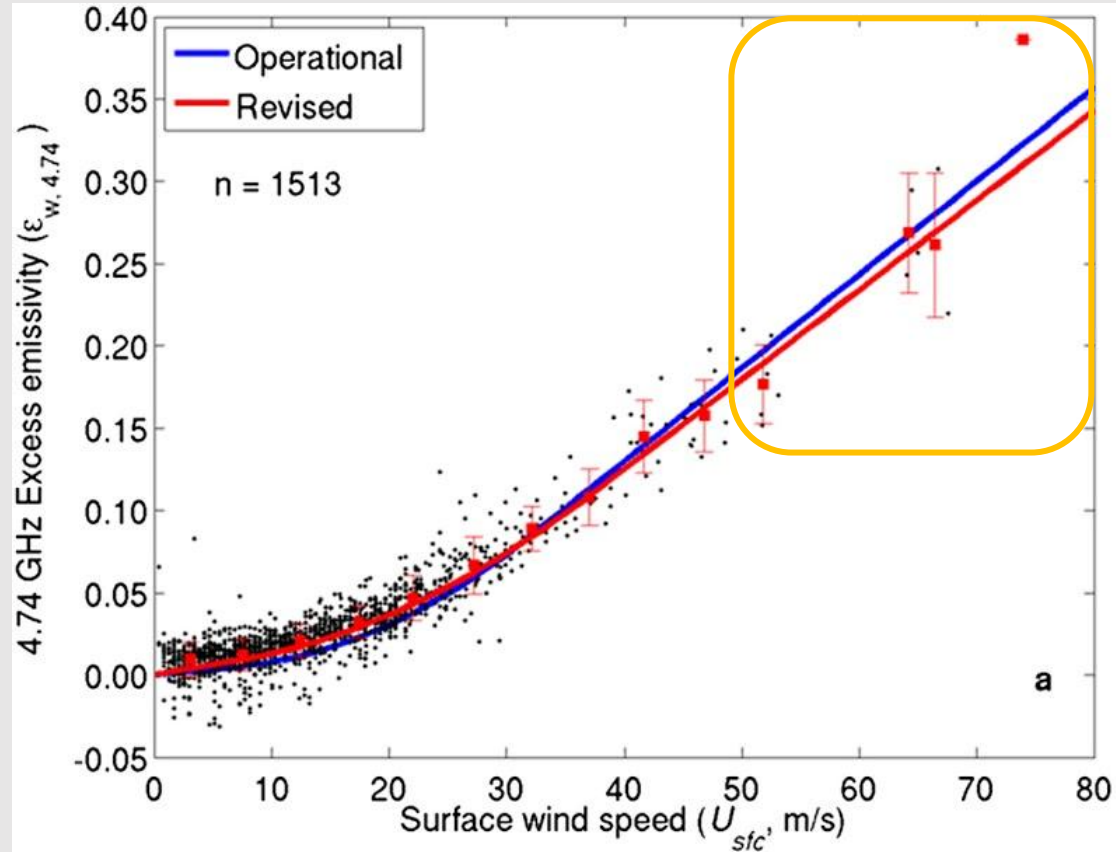
SFMR Algorithm



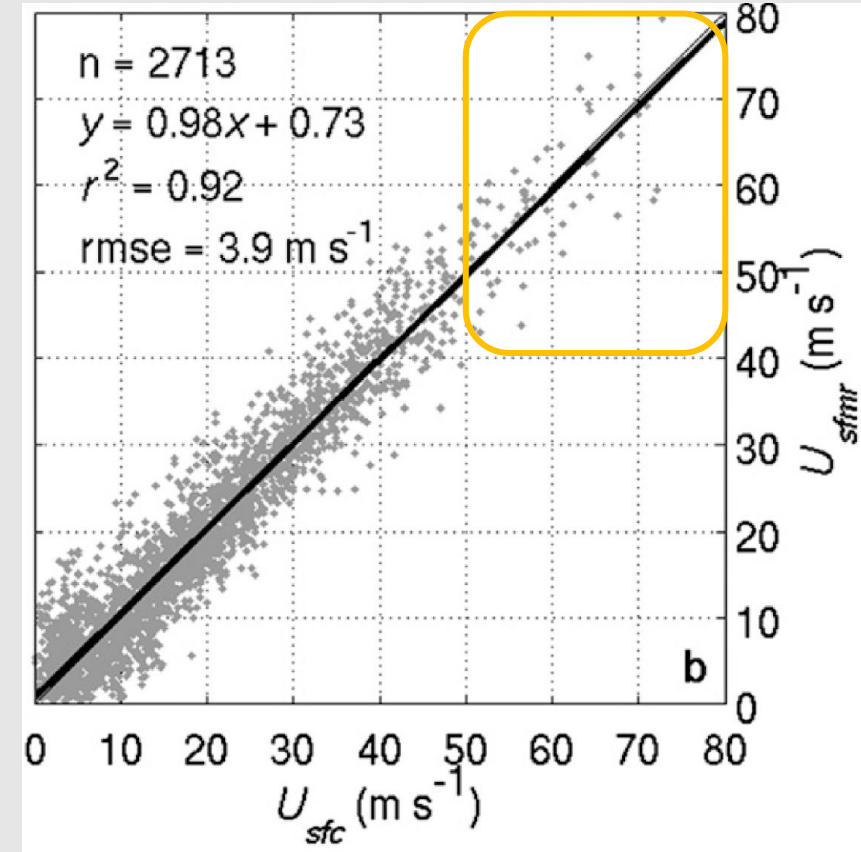
Previous Algorithm Update

Revised = Klotz and Uhlhorn (2014)

Operational = Uhlhorn et al. (2007)



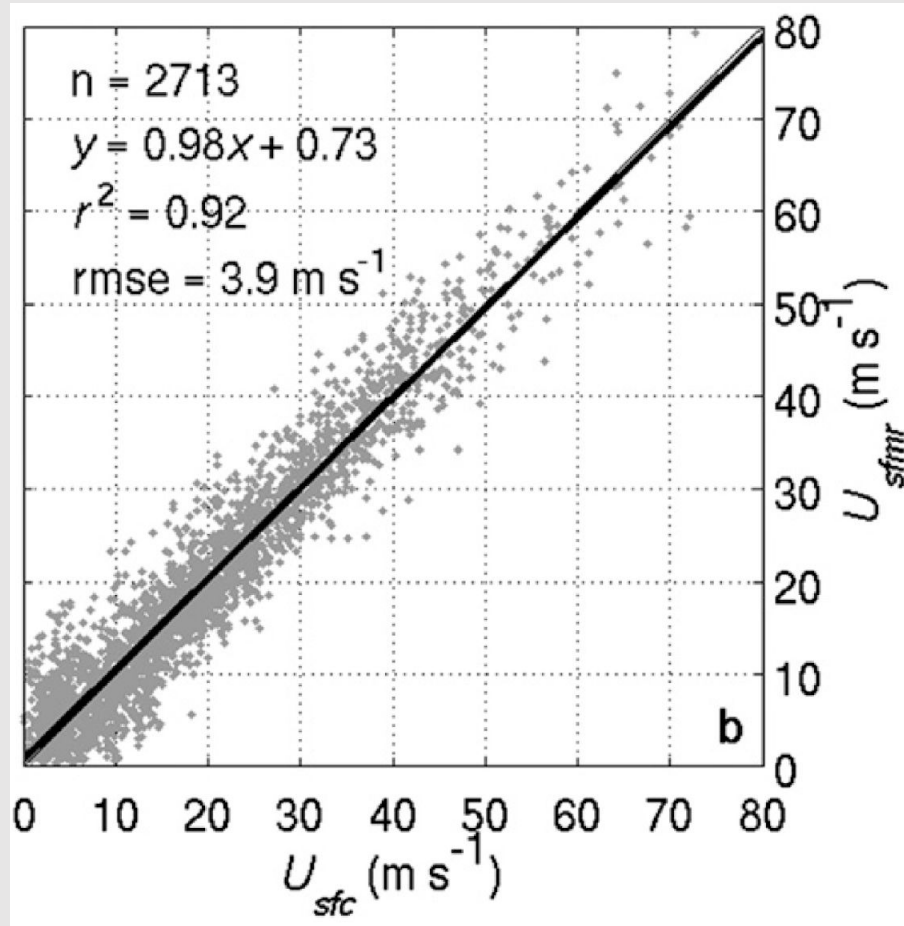
Klotz and Uhlhorn (2014) Fig. 3a



Klotz and Uhlhorn (2014) Fig. 11b

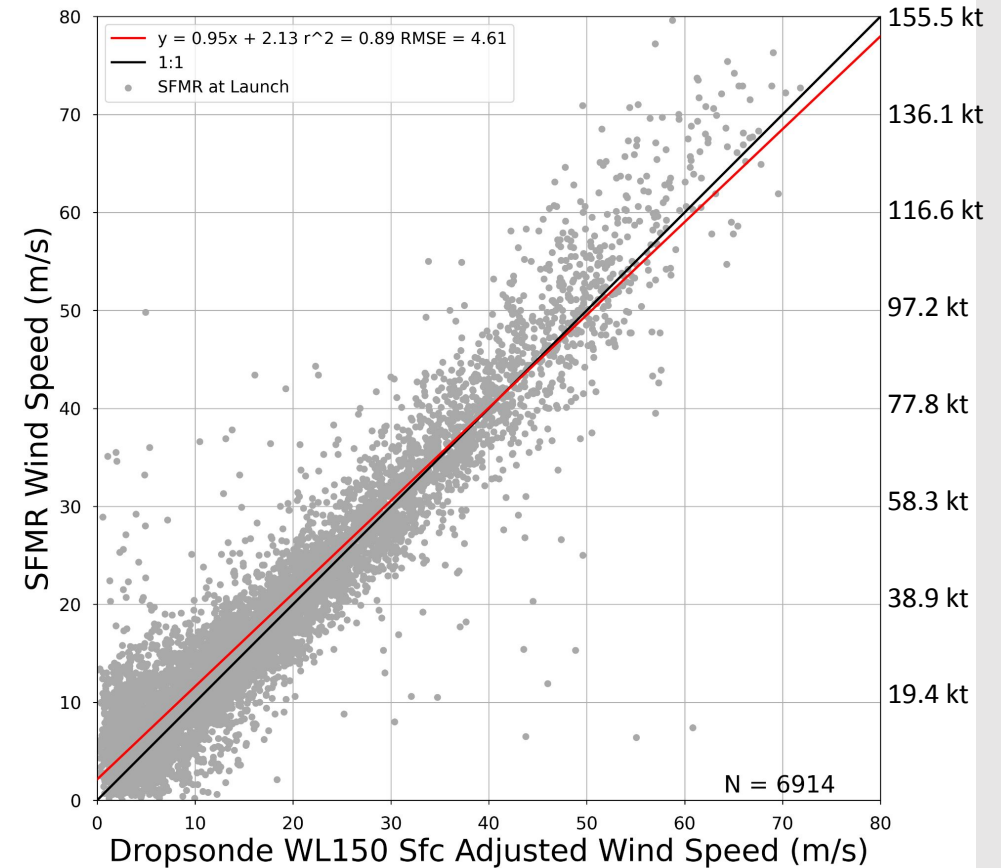
Current Wind Speed Fit

2005 to 2012



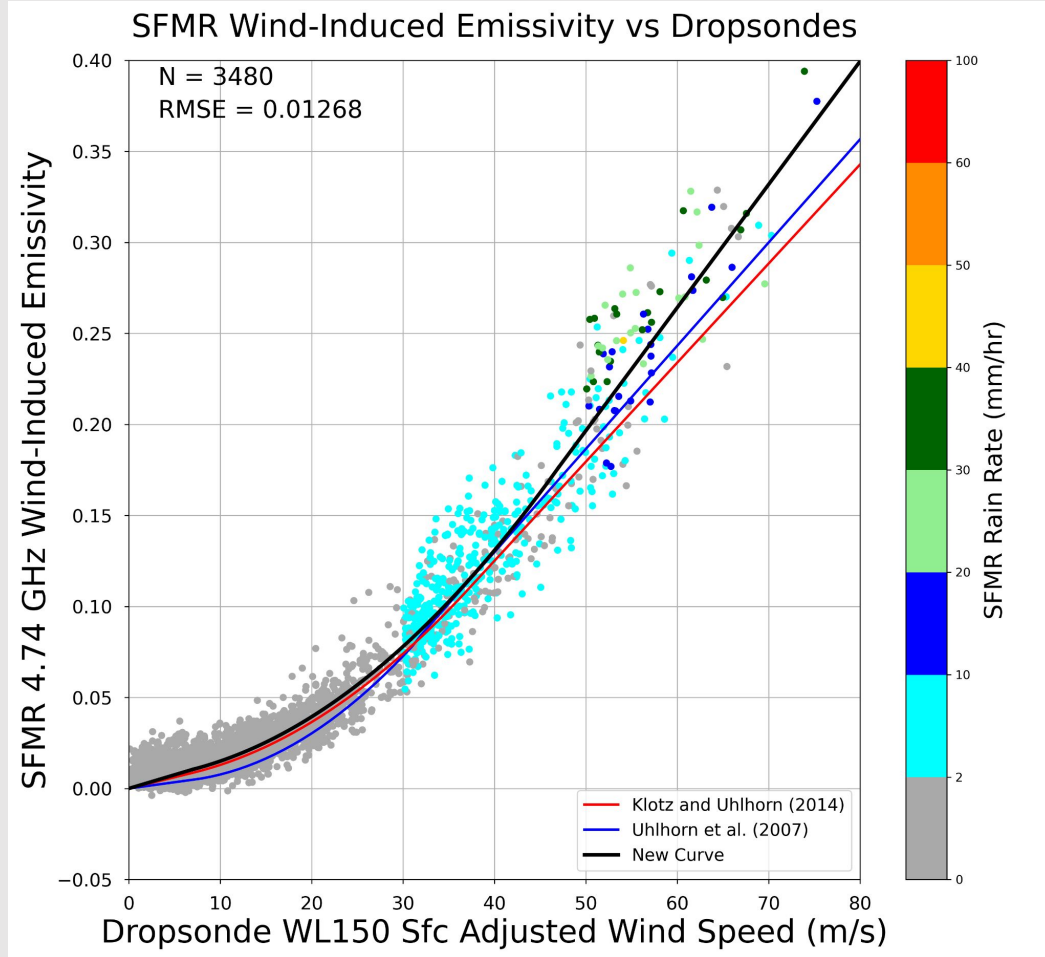
Klotz and Uhlhorn (2014) Fig. 11b

SFMR vs Dropsondes 2004 to 2020

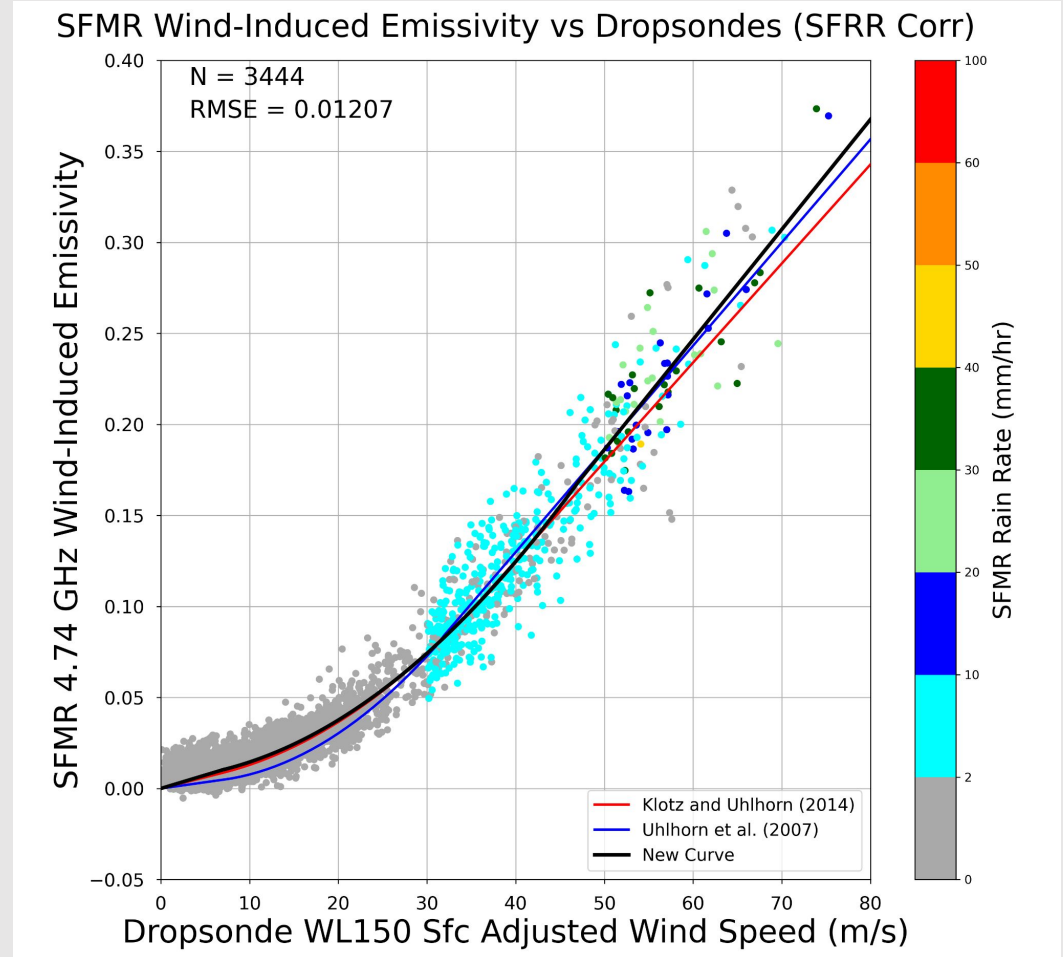


Updating SFMR Wind-Induced Emissivity Curve

Using 0 mm/hr

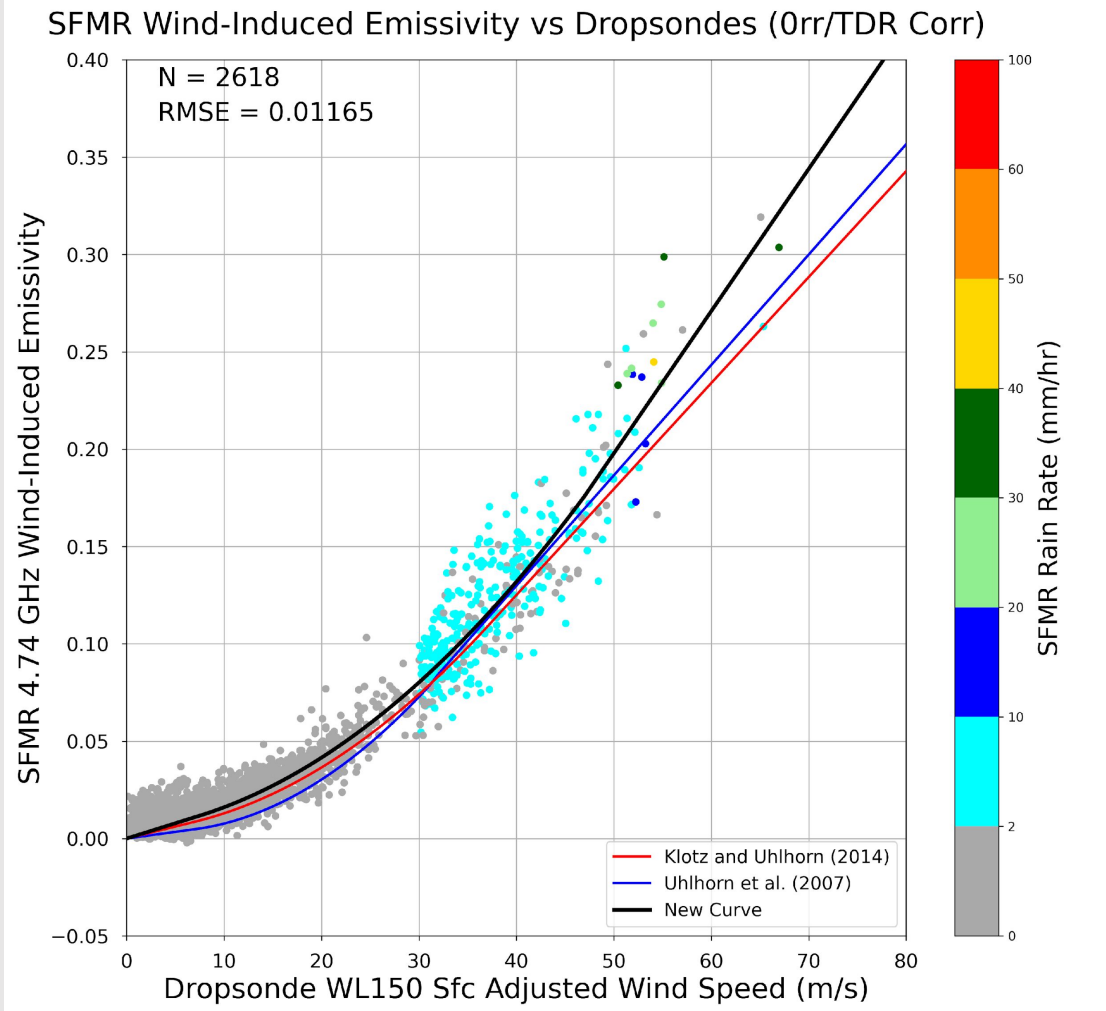


Using SFMR rain rate



Klotz and Uhlhorn (2014) TDR Z-R Relationship: $Z = 456R^{1.07}$

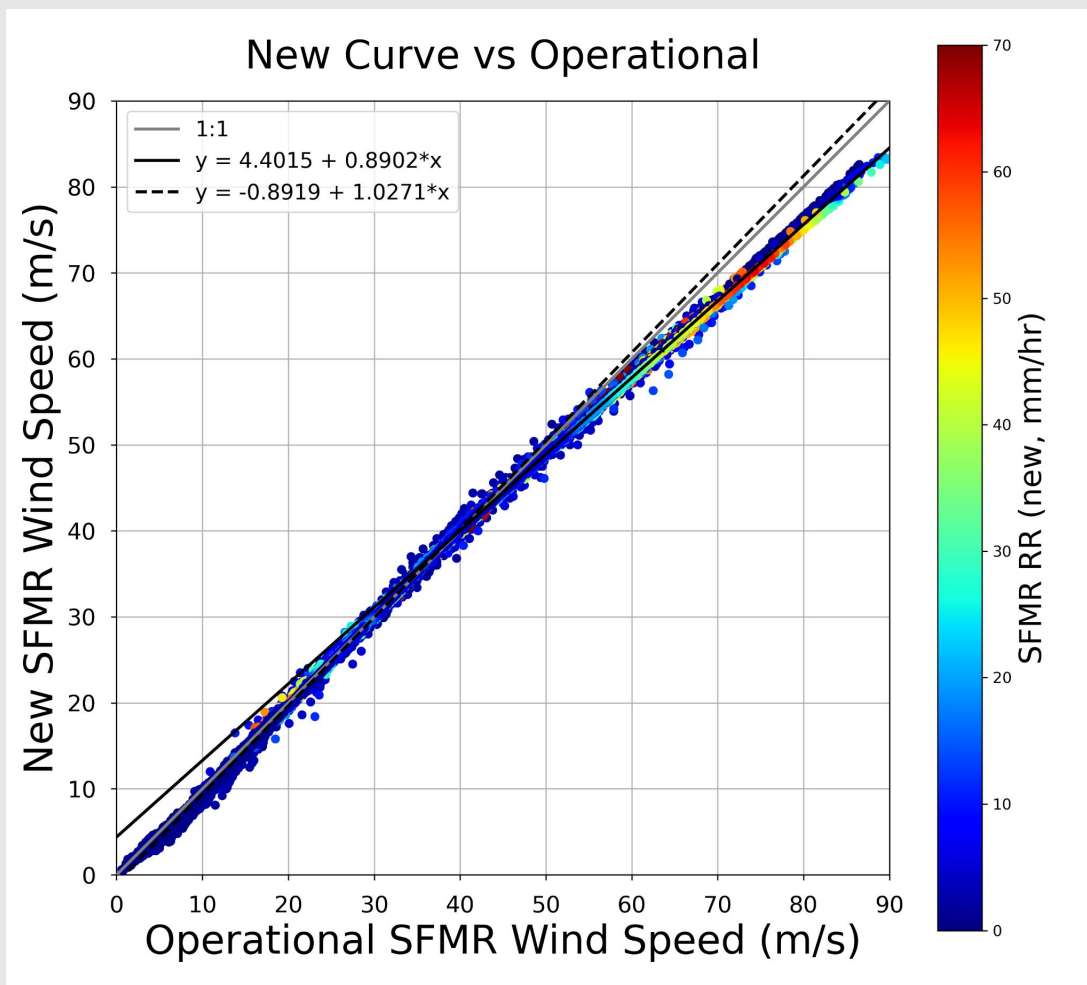
TDR Rain Rate



- Challenges:

- TDR data only available for NOAA flights
- TDR reflectivity is not calibrated
 - Between P-3s or to external “truth”
- KU2014 Z-R developed using ad-hoc 7dB “correction”
- SFMR and TDR rain rate generally show similar trend, but peaks are sometimes misaligned

Preliminary Wind Speed Adjustments



Operational (m/s)	Revised (m/s)
40	40.0
45	44.5
50	48.9
55	53.4
60	57.8
65	62.3
70	66.7
75	71.2
80	75.6
85	80.1
90	84.5

Operational (kt)	Revised (kt)
75	75.3
80	79.8
85	84.2
90	88.7
95	93.1
100	97.6
105	102.0
110	106.5
115	110.9
120	115.4
125	119.8
130	124.3
135	128.7
140	133.2
145	137.6
150	142.1
155	146.5
160	151.0
165	155.4
170	159.9
175	164.3
180	168.8

Next Steps and Transition Timeline

- Need to determine how to correct TDR reflectivity data
 - Can we use Z-R relationship from Klotz and Uhlhorn (2014) or do we need to develop a new Z-R relationship for each year to account for TDR calibration changes?
- Goal is to run new algorithm updates in tandem with current operational algorithm on P-3s for 2022 season
 - Possibly visit NHC to work with forecasters during 2022 season
- Undergo peer-review and publish results during summer/fall 2022
- Possible transition of algorithm updates for 2023 season

Other SFMR topics

- All aircraft should be flying with new processors this season
- Calibration quality
- HDOB Flag update
 - Waiting to see how new processors impact number of HDOB flags
- Quality of SFMR data at higher altitudes
- Azimuthal wave dependencies

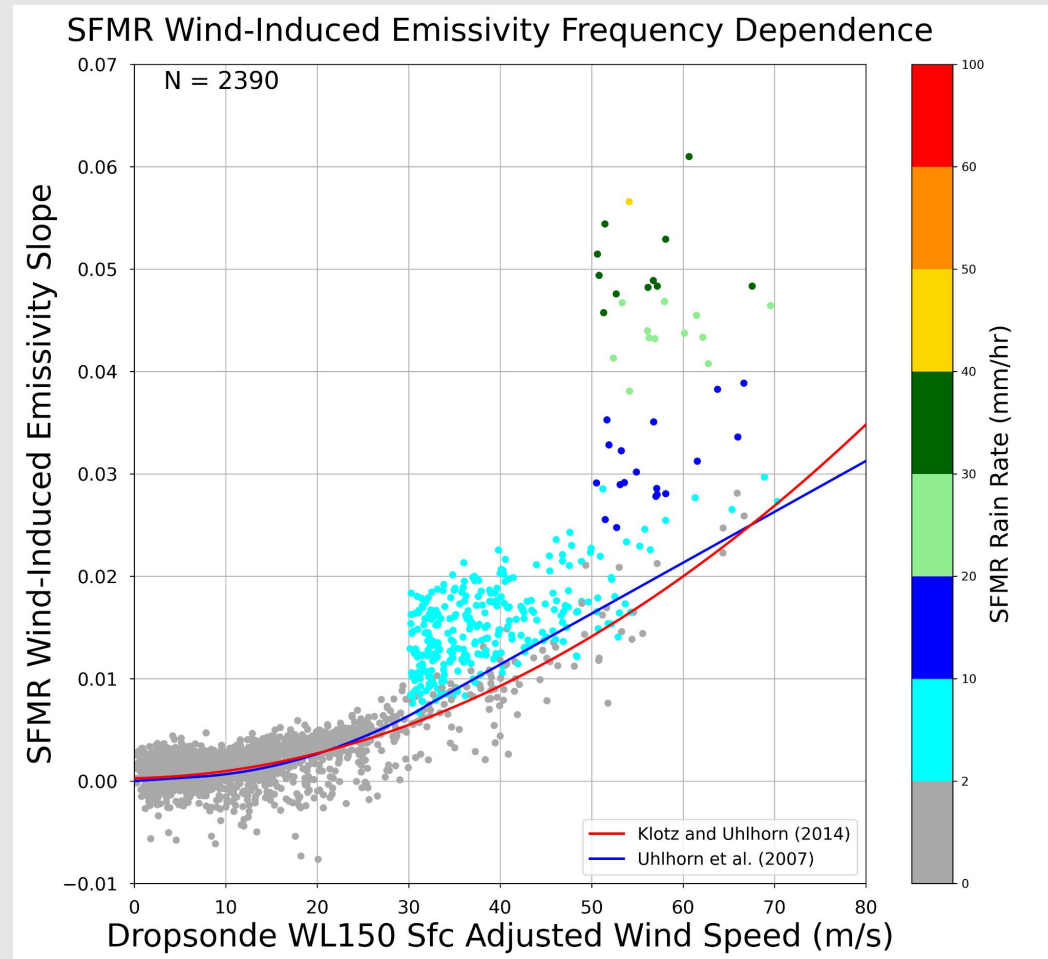
Backup Slides



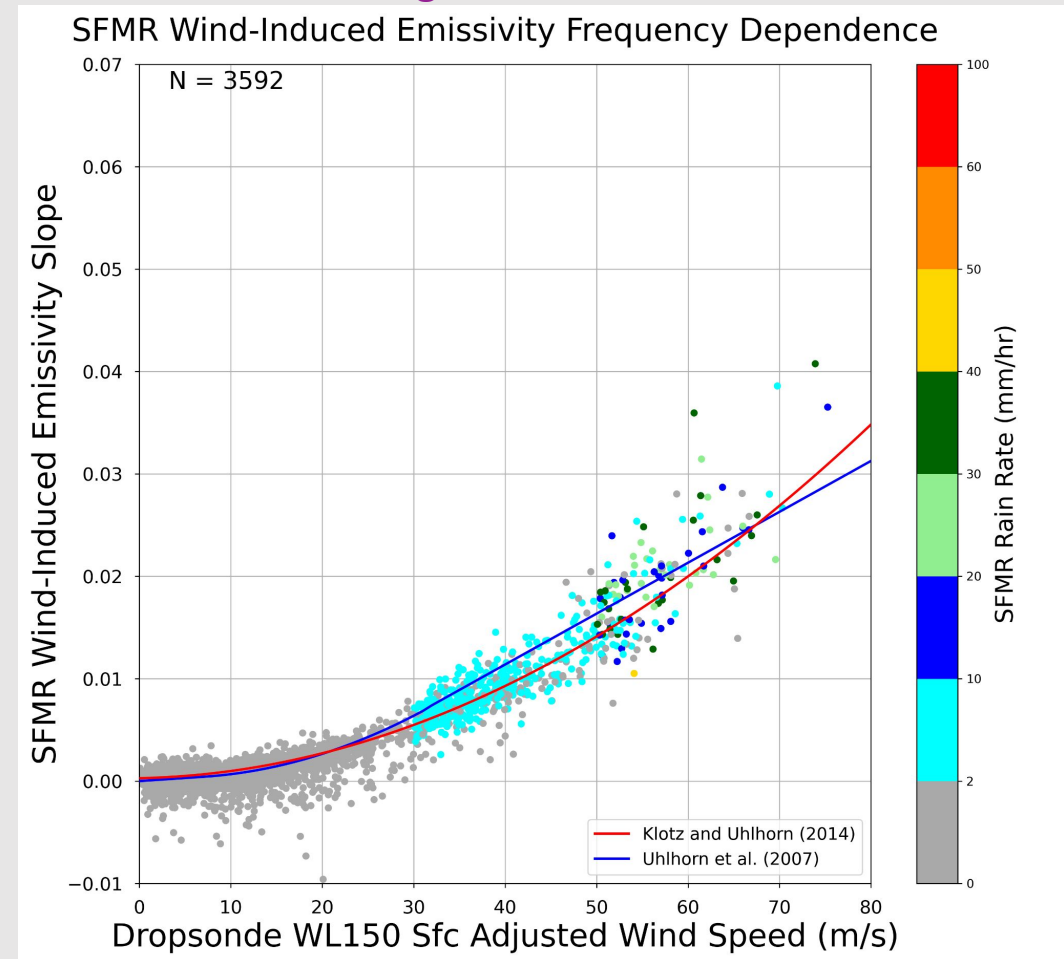
Frequency Dependence

$$\frac{\partial \epsilon_w}{\partial f}$$

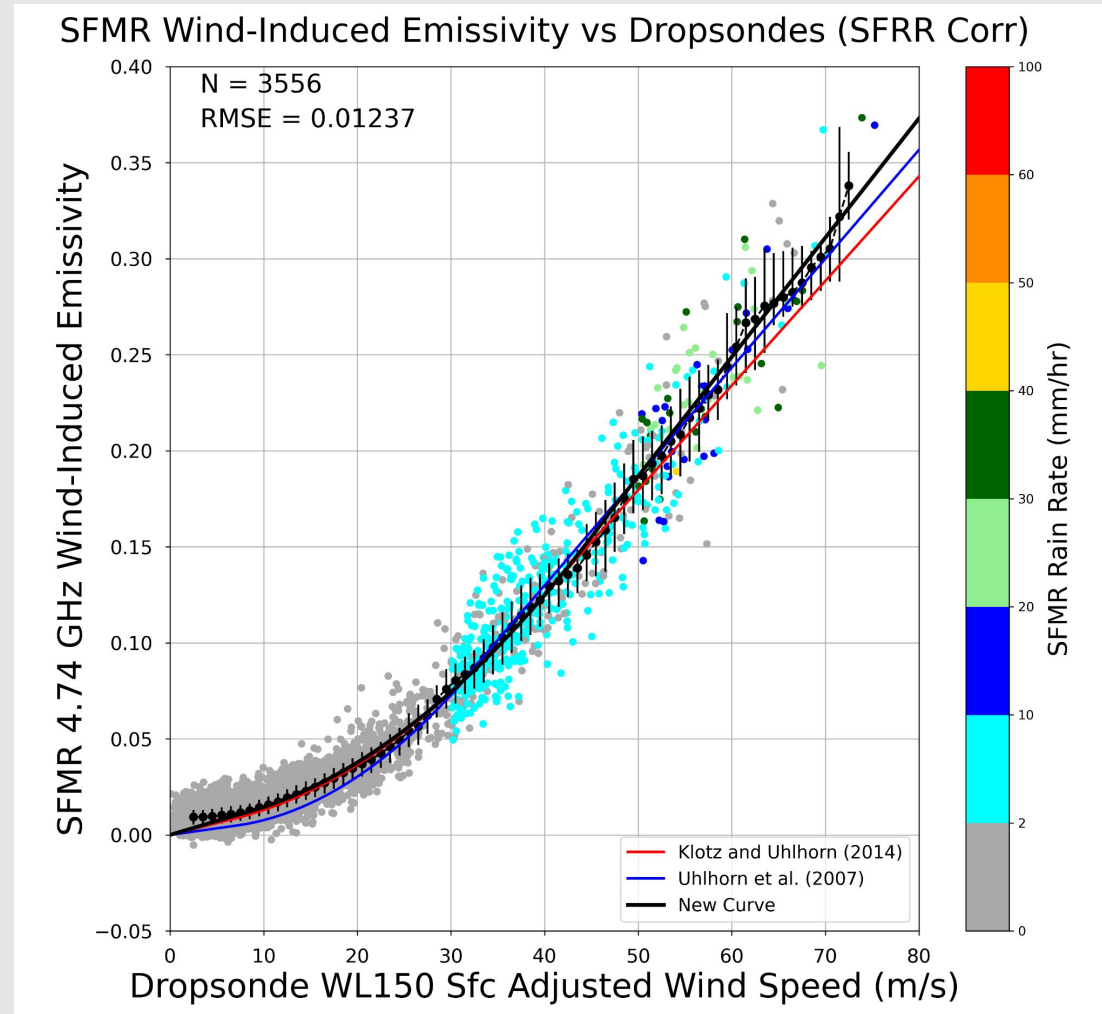
Using 0 mm/hr



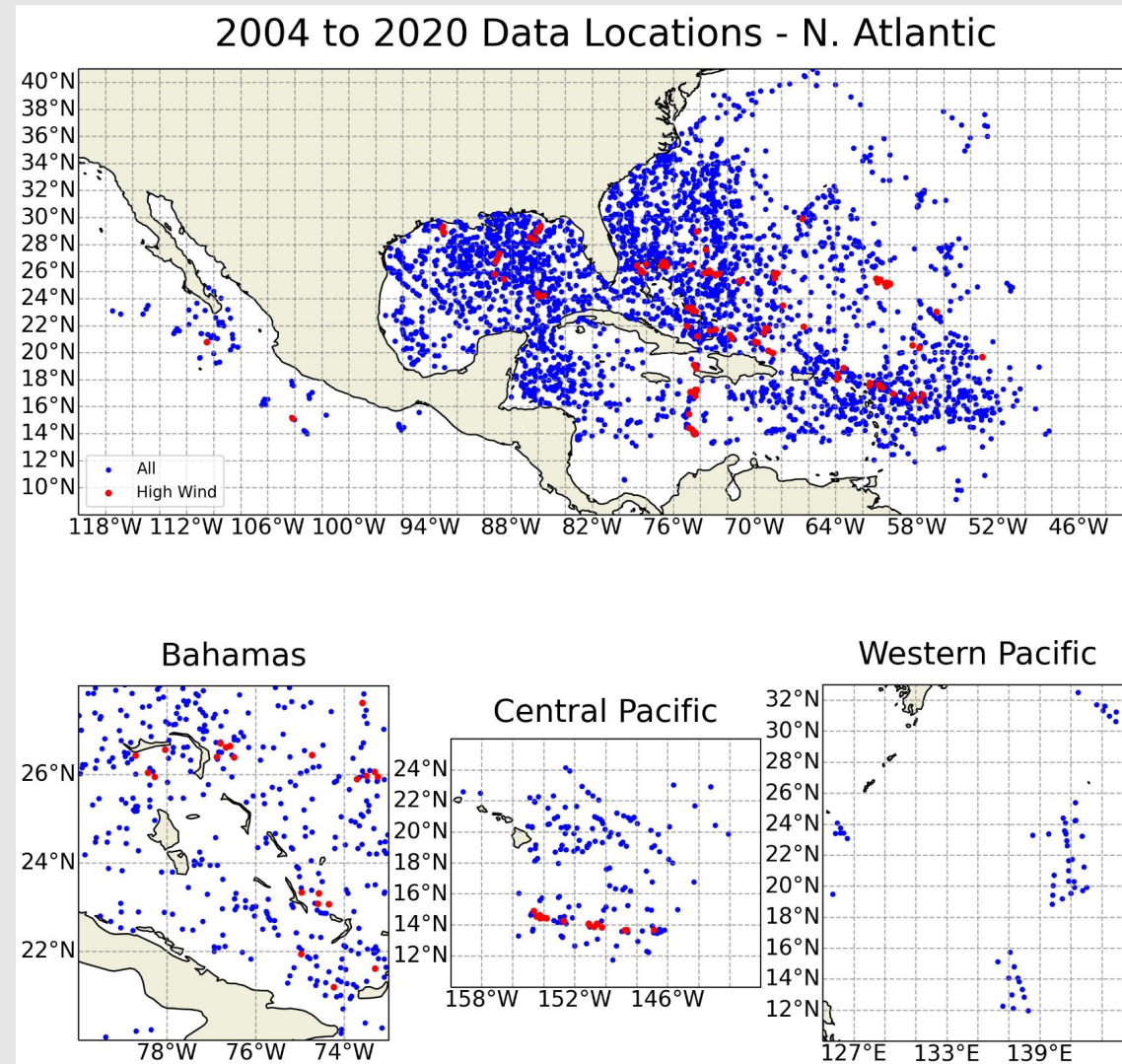
Using SFMR rain rate



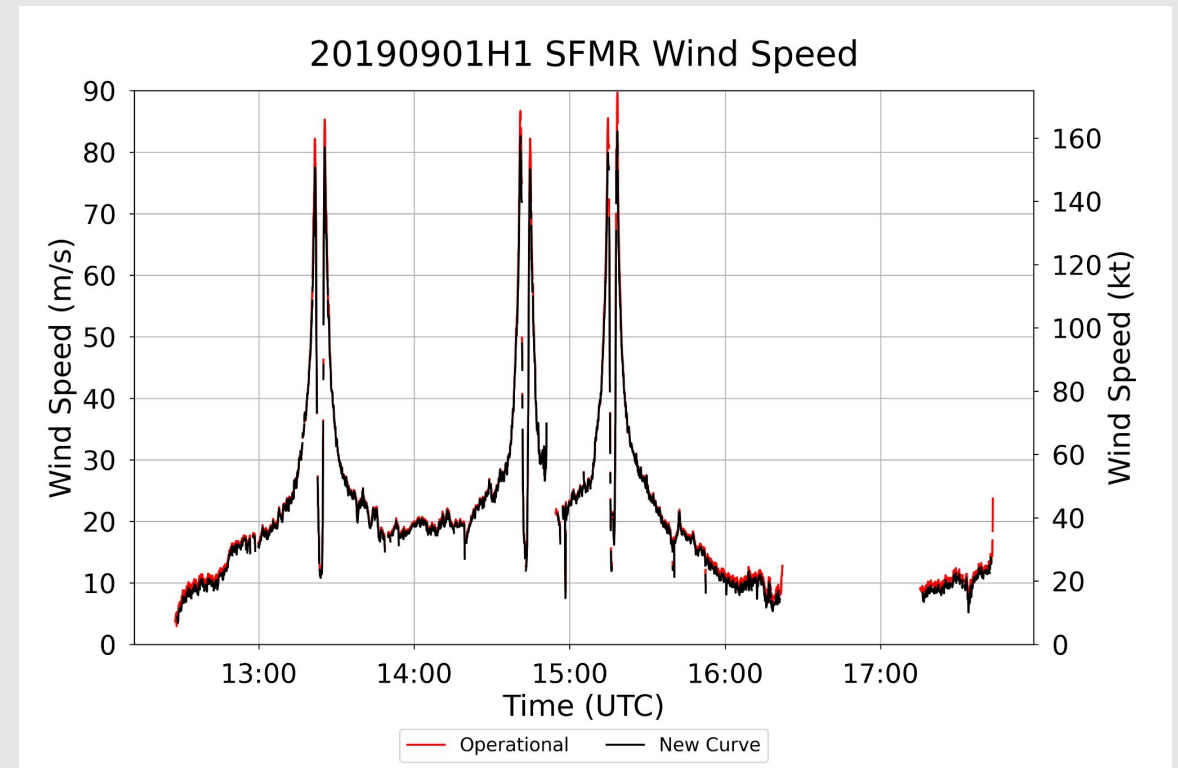
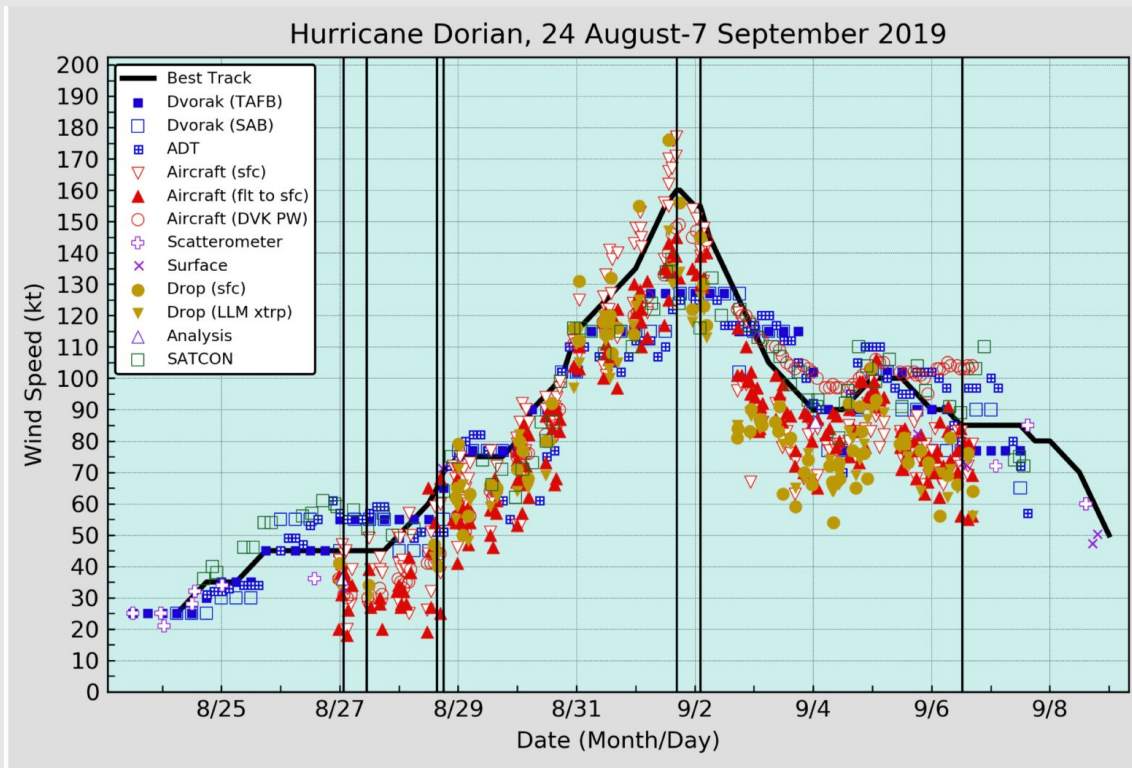
Wind-Induced Emissivity Bins



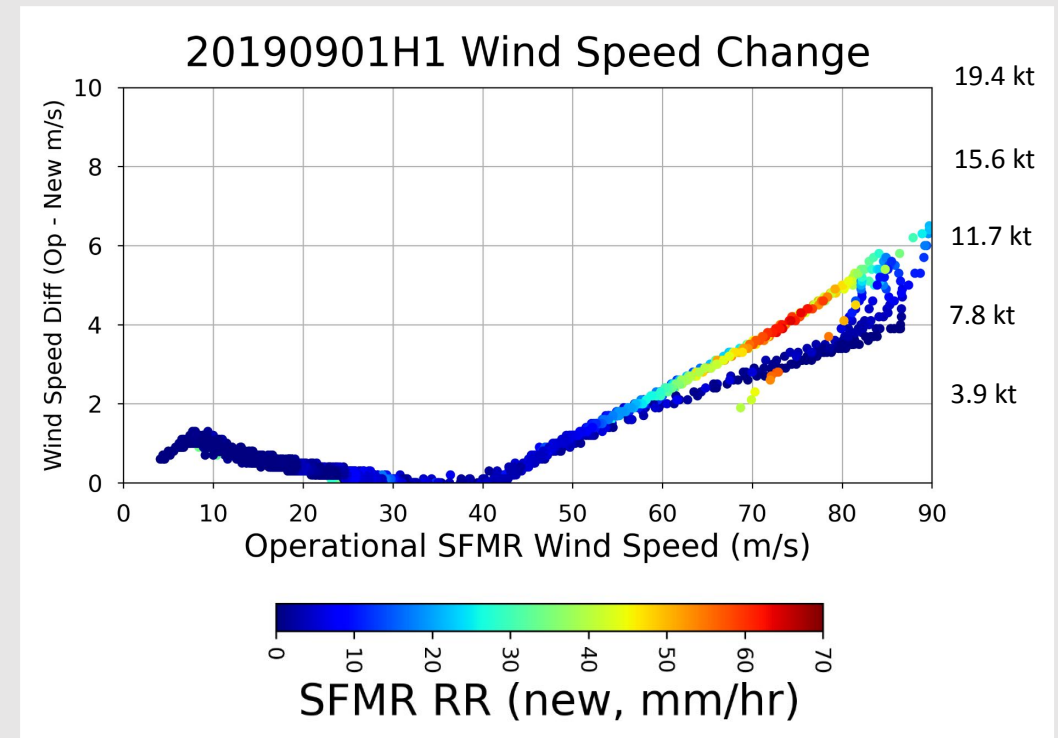
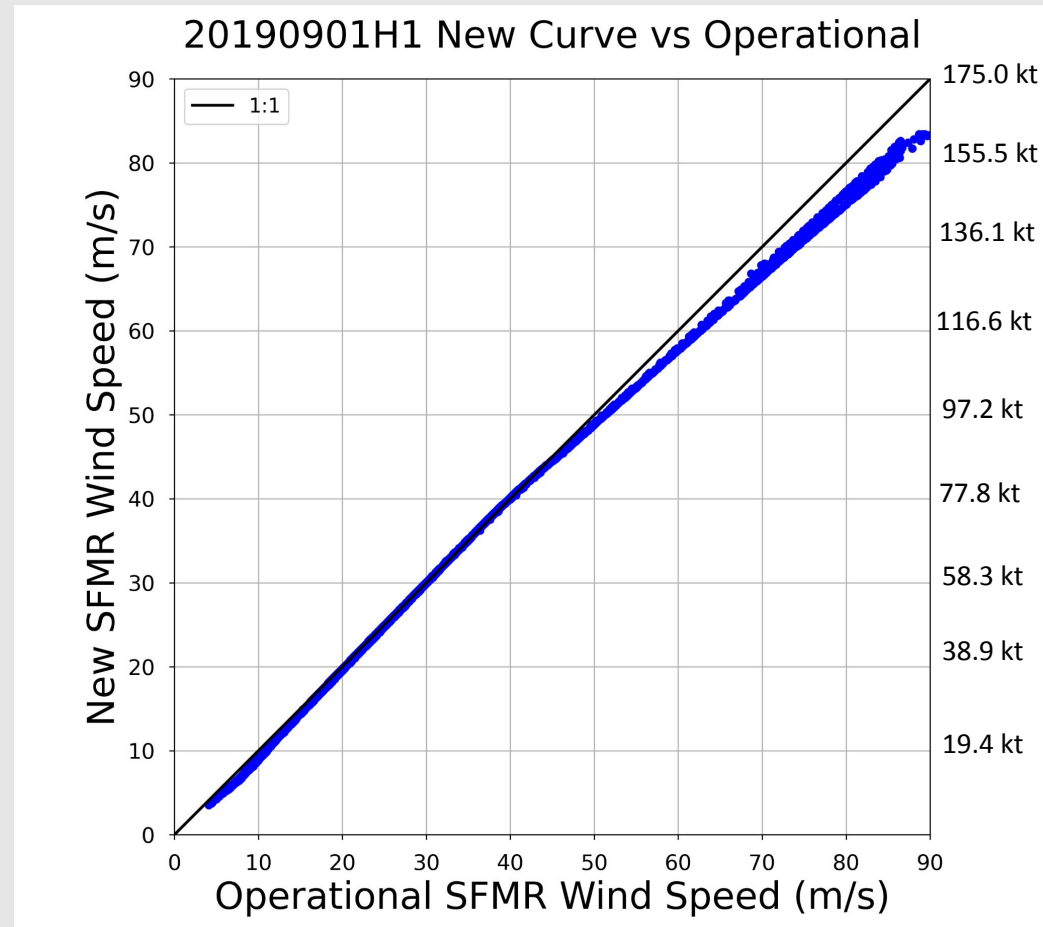
Data Locations



Hurricane Dorian (2019)



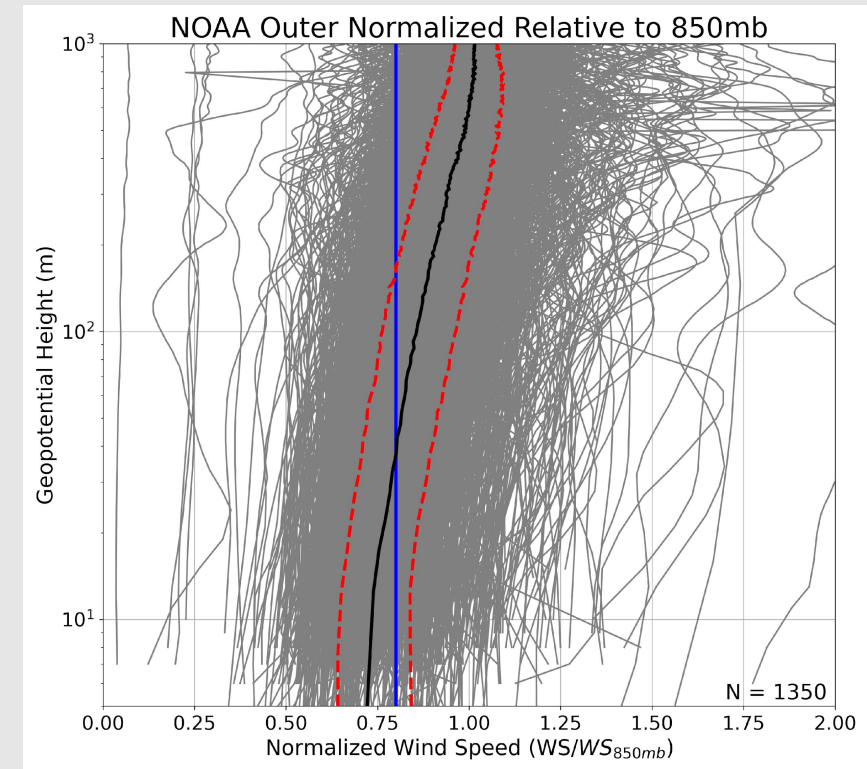
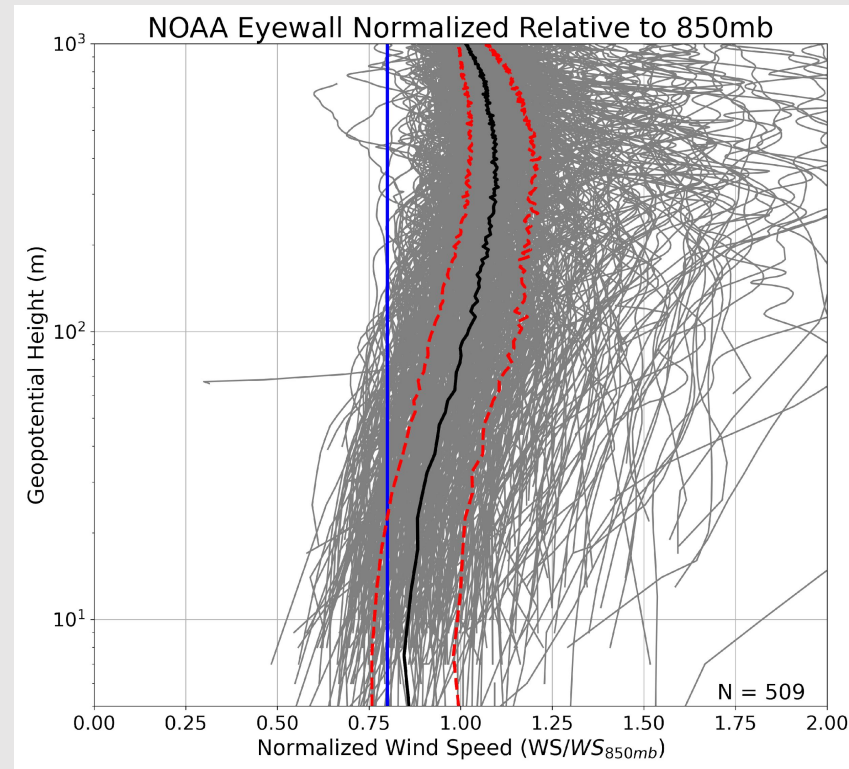
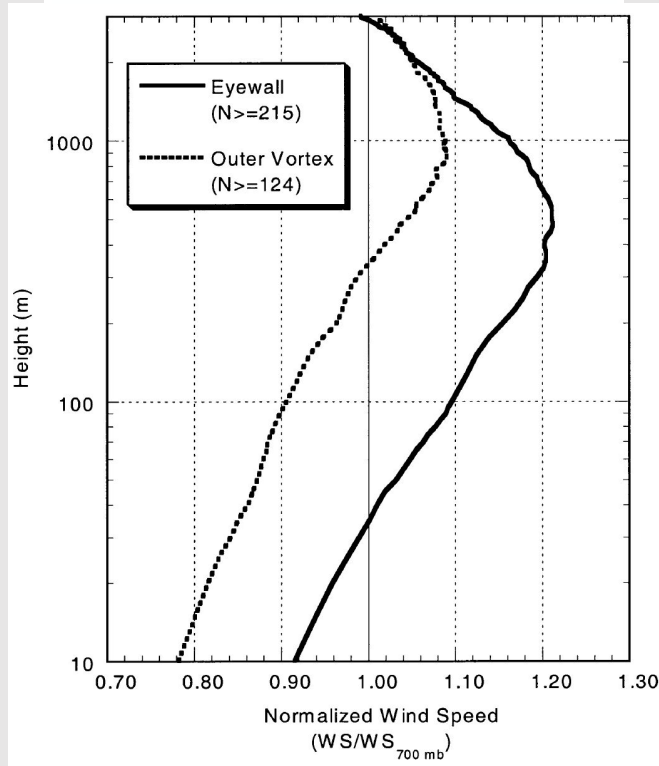
Hurricane Dorian (2019)



Re-evaluating Flight-Level Wind Reduction

TABLE 2. Recommended operational wind adjustment factors for adjusting reconnaissance flight-level winds to the surface, for the hurricane-eyewall and outer-vortex regions.

Flight level	Eyewall	Outer vortex (convection)	Outer vortex (not in convection)
700 hPa	0.90	0.85	0.80
850 hPa	0.80	0.80	0.75
925 hPa	0.75	0.75	0.75
1000 ft (305 m)	0.80	0.80	0.80

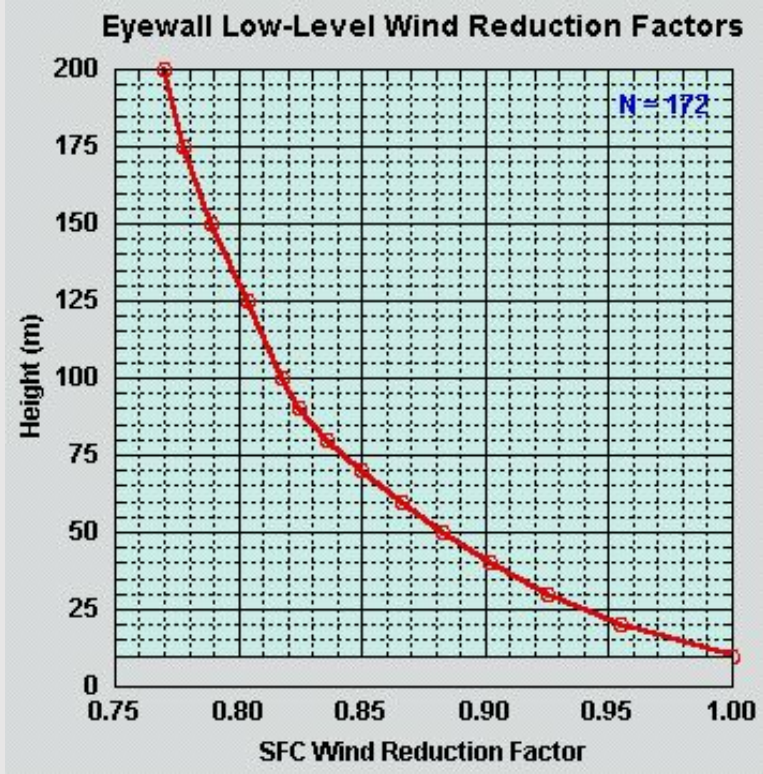


Blue: Franklin et al. (2003) wind reduction factor

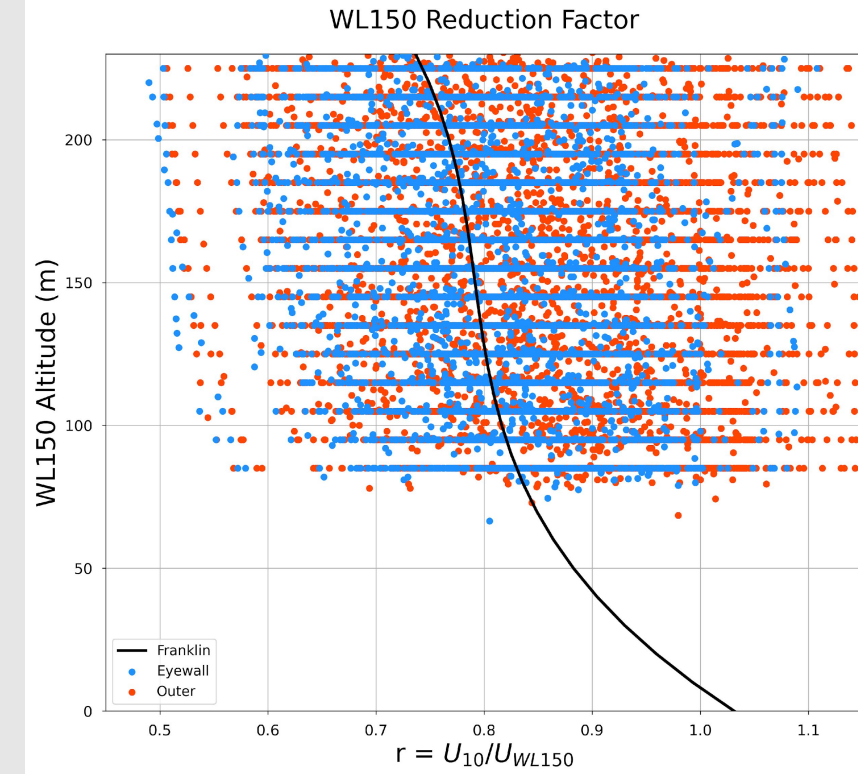
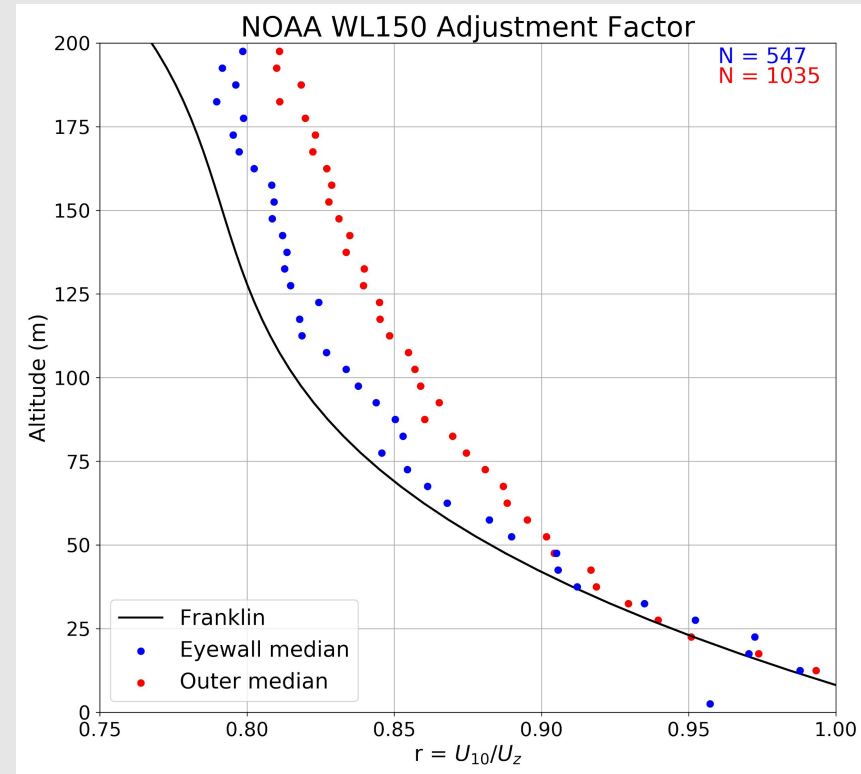
Black: Median profile

Red: 25th and 75th percentile profiles

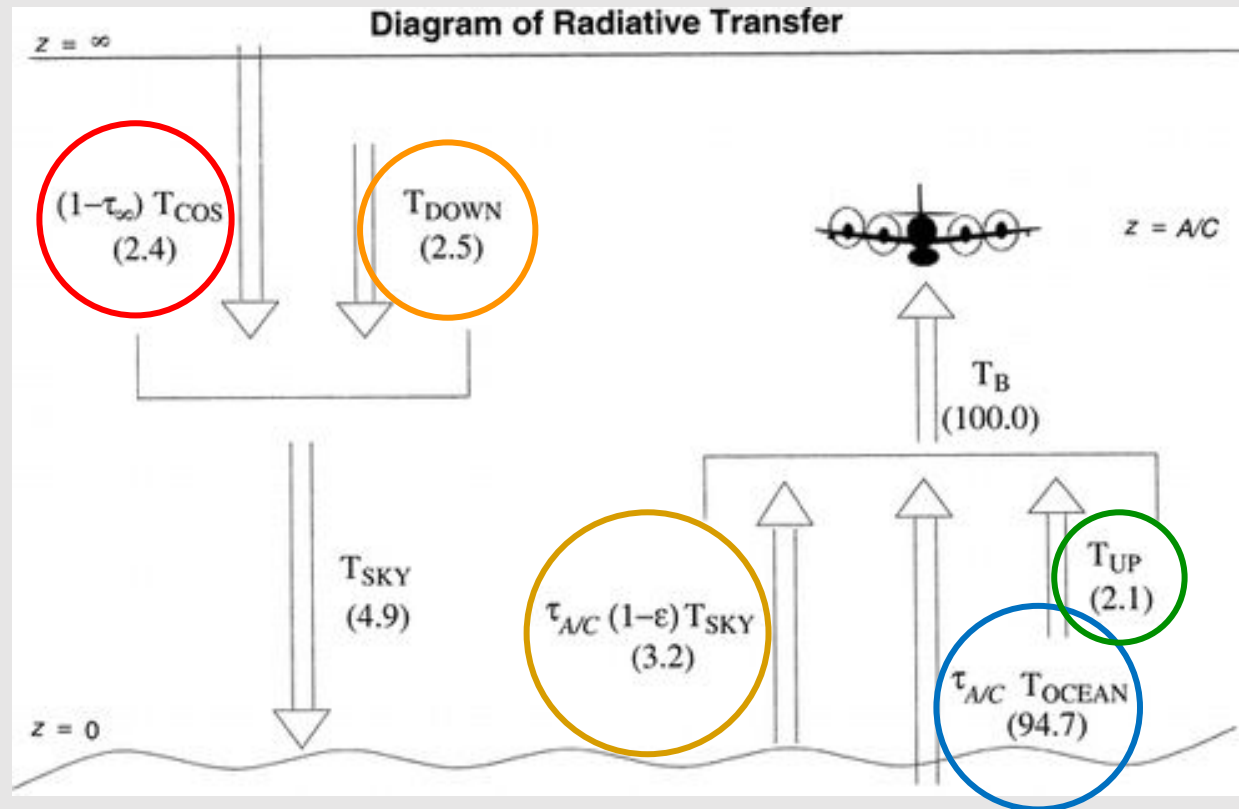
Re-evaluating Dropsonde WL150 Reduction Factor



Franklin et al. (2003)



SFMR Radiative Transfer Model

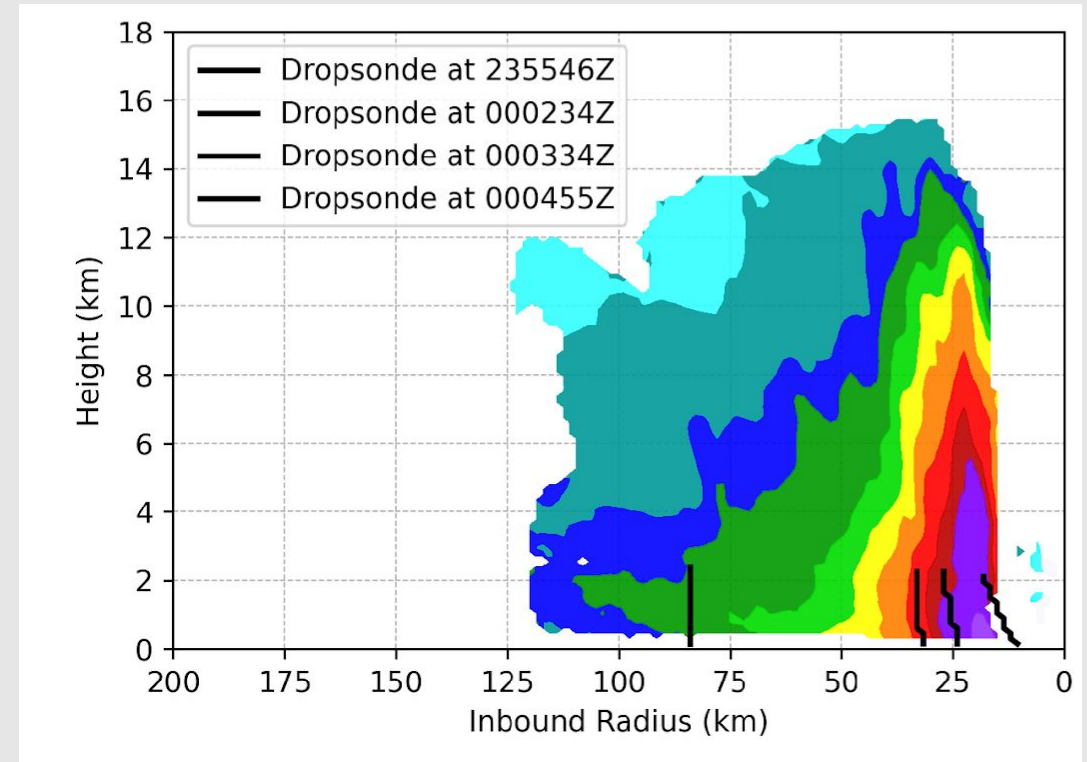
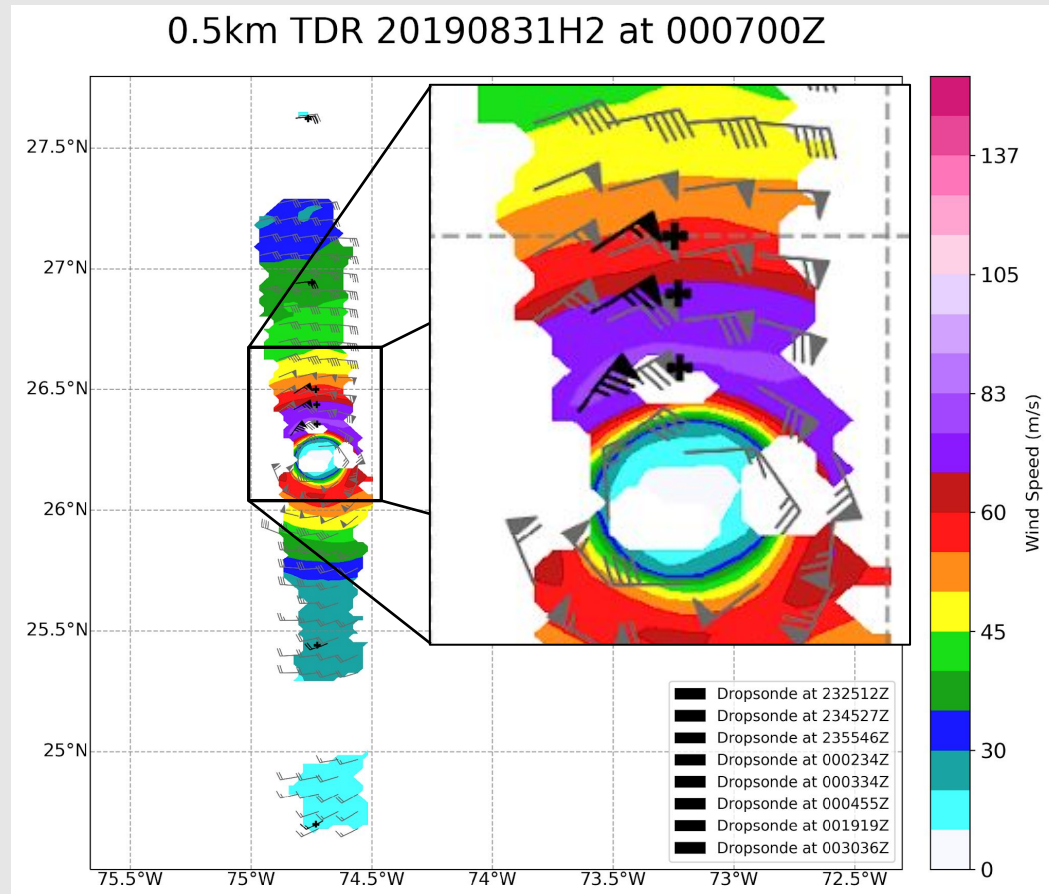


τ : transmissivity
 T : temperature
 A/C : layer beneath aircraft
 ∞ : entire column

Uhlhorn and Black (2003)

SFMR measured T_B = reflected cosmic radiation (T_{COS}) + reflected downward emission from atmosphere (T_{DOWN}) + emission from surface (T_{OCEAN}) + upward emission from atmosphere (T_{UP})

Colocation Difficulties in High Winds



Dropsonde Overflights

SFMR and Dropsondes 20190928I1

